2002 CleanEnergy Seminar, Sacramento

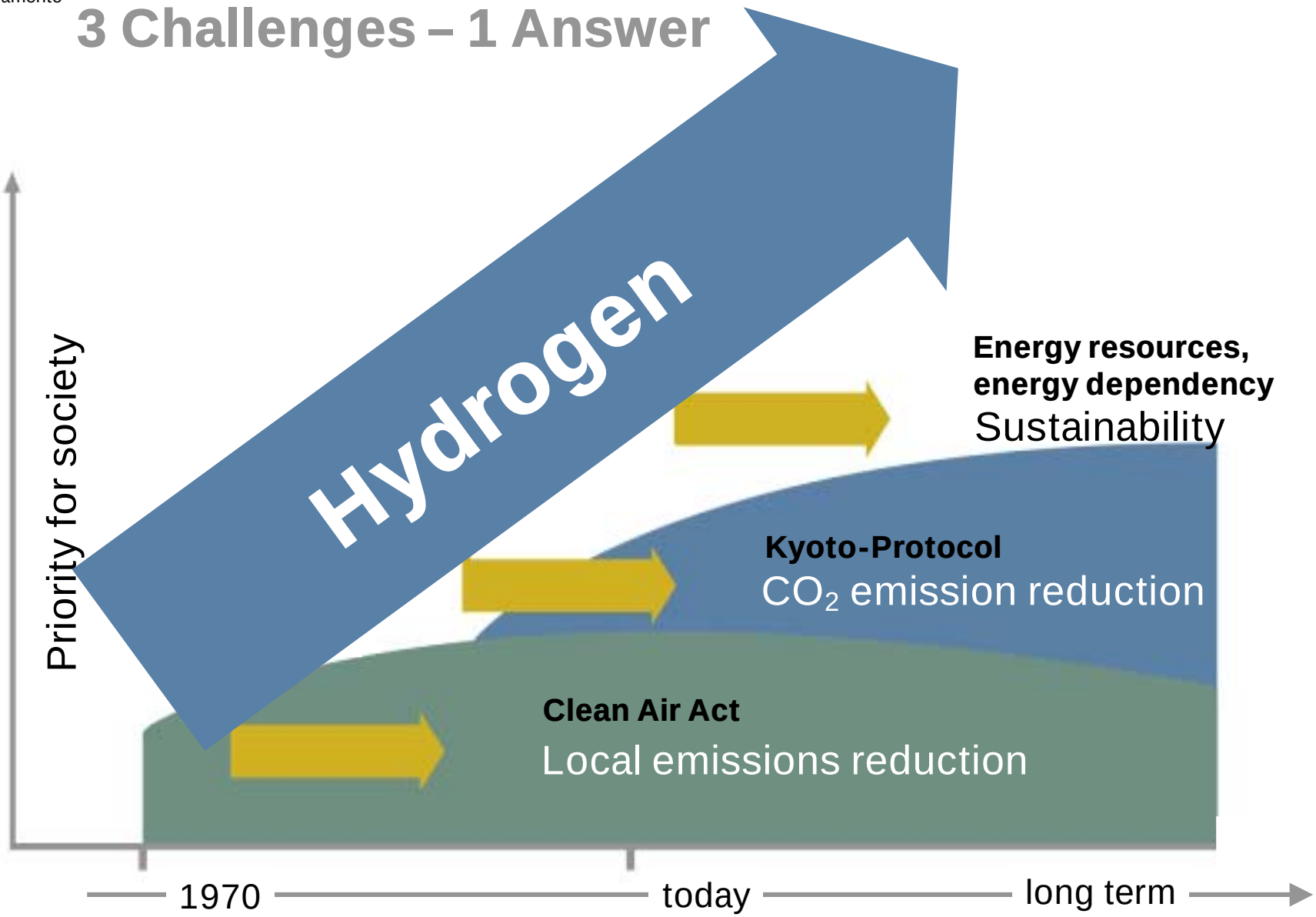
Christoph Huss

Importance of CleanEnergy for the Automobile Industry

BMW Group

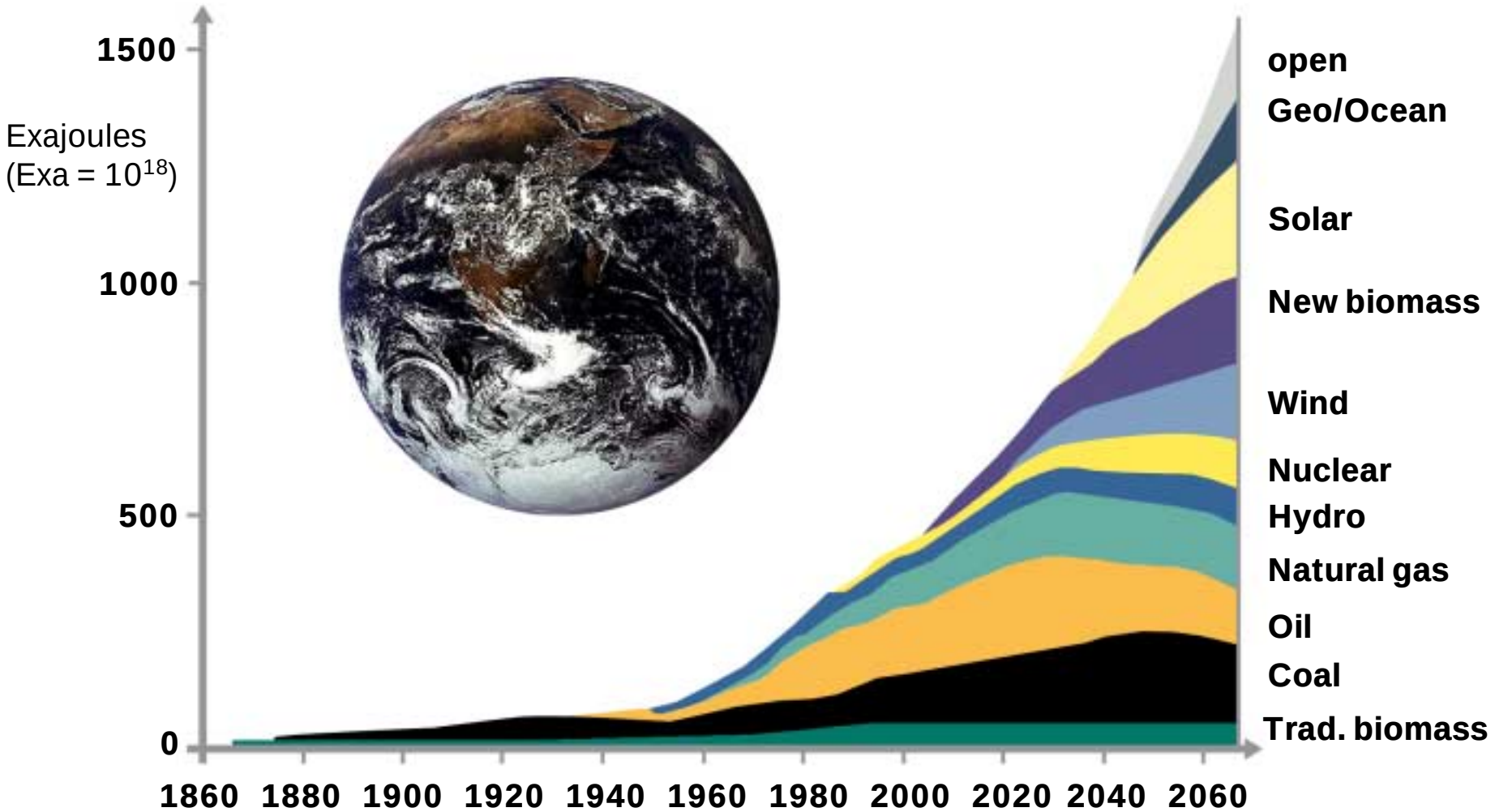
Hydrogen

3 Challenges – 1 Answer



[Source: based on Honda-Publication]

World Energy Demand
Sustained Growth Scenario



Source: Shell AG

Climate Change – Greenhouse Effect

Reduction Targets for Greenhouse Gas Emissions

Rio Conference (UN Framework Convention on Climate Change)

- The ultimate objective.....is the stabilization of greenhouse gas concentrations…at a level that would prevent dangerous anthropogenic interference with the climate system.

Kyoto Protocol

- Reduction of CO_2 equivalent emissions at least 5% below 1990 levels in the period 2008 to 2012 (developed countries)
  - European Community - 8%
  - Germany - 21%

European Commission (interpretation of IPCC results)

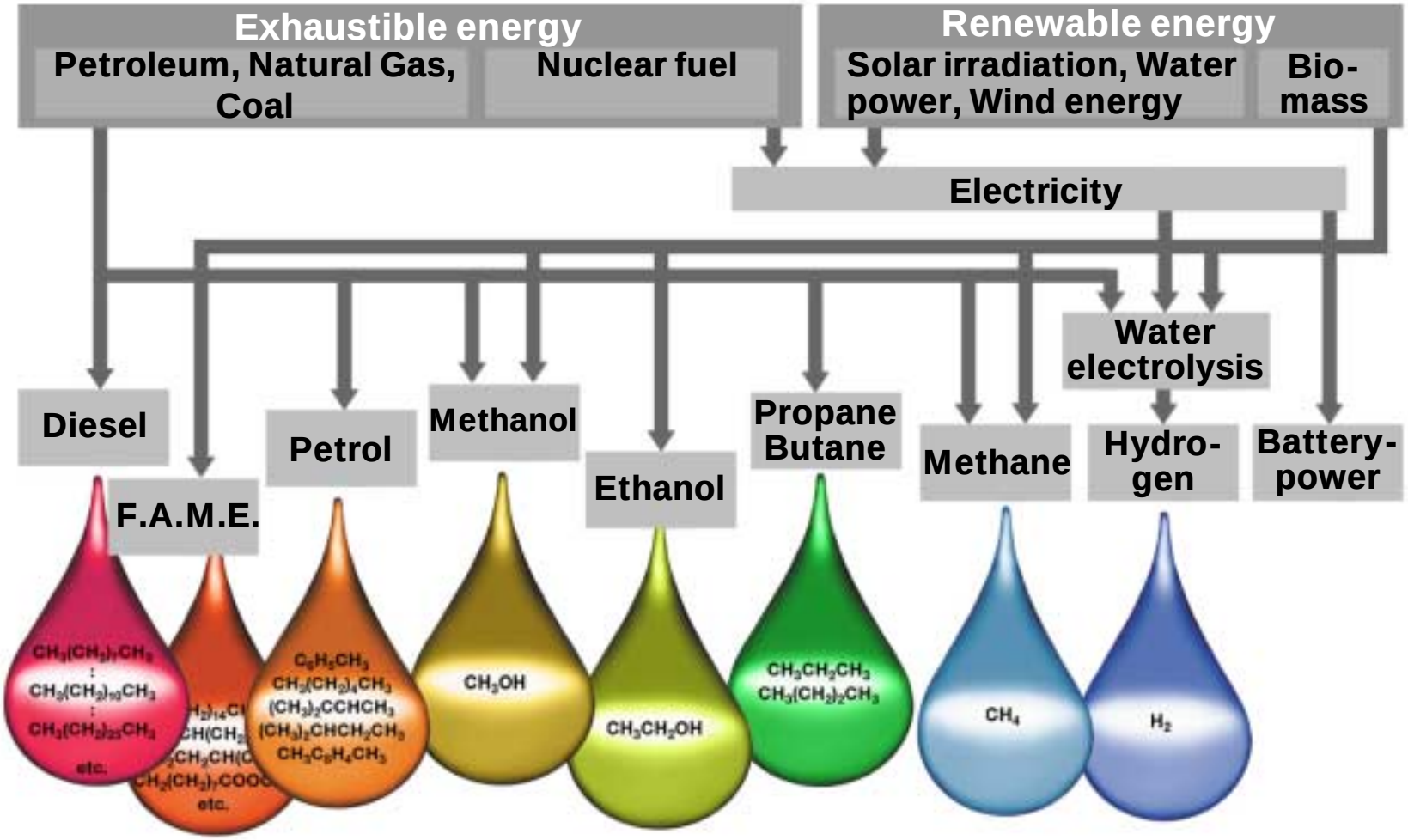
- medium term: Reduction of worldwide CO_2 emissions by 20-40% by 2020
- long term: Reduction of worldwide CO_2 emissions by 70%

BMW (technological interpretation):

- Evolution towards carbon free fuels → hydrogen

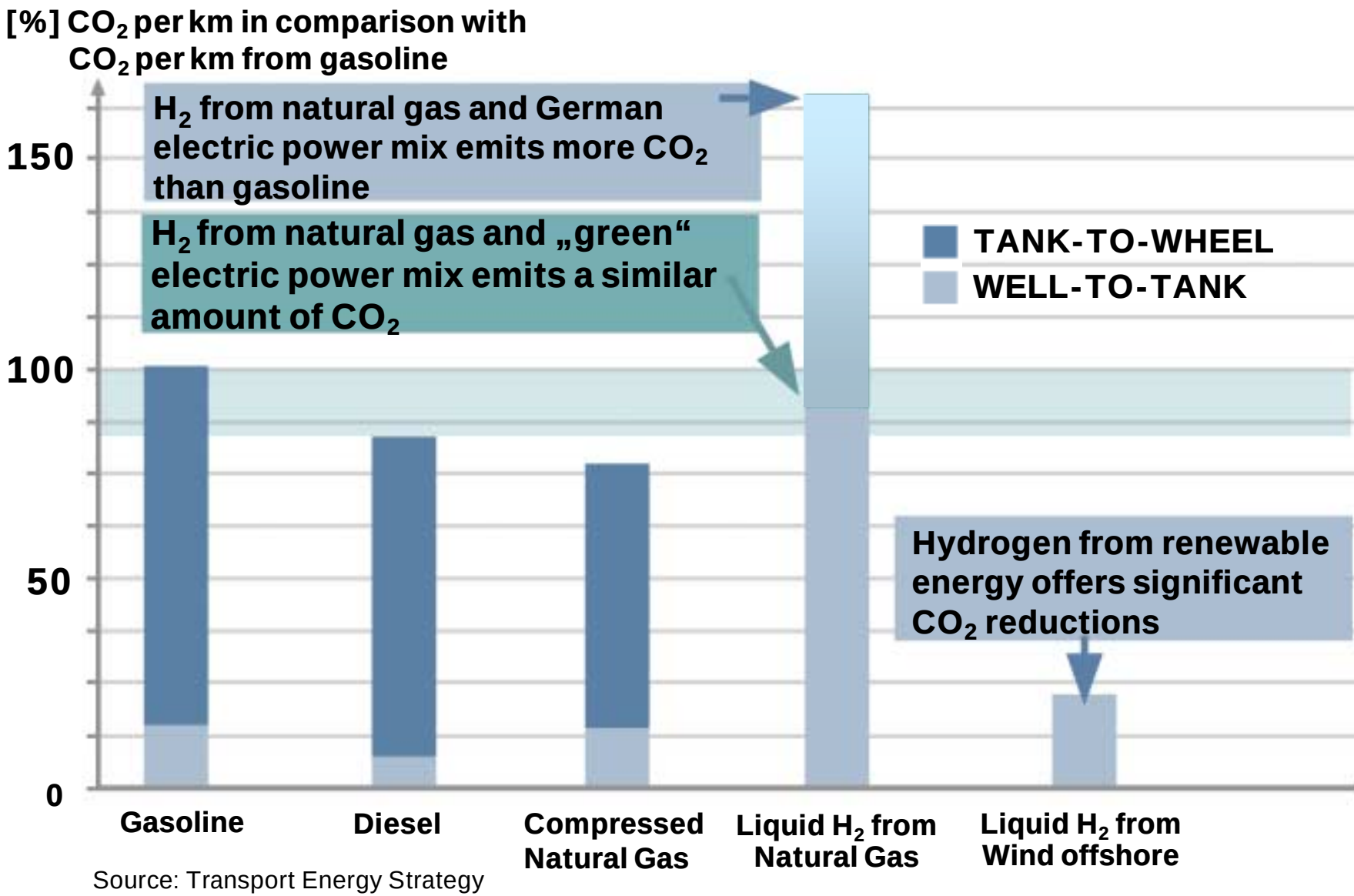
Possible Types of Fuels for Transportation

Different Fuel Supply Chains Well-to-Tank



Well-to-Wheel CO_2 Emissions of ICE's

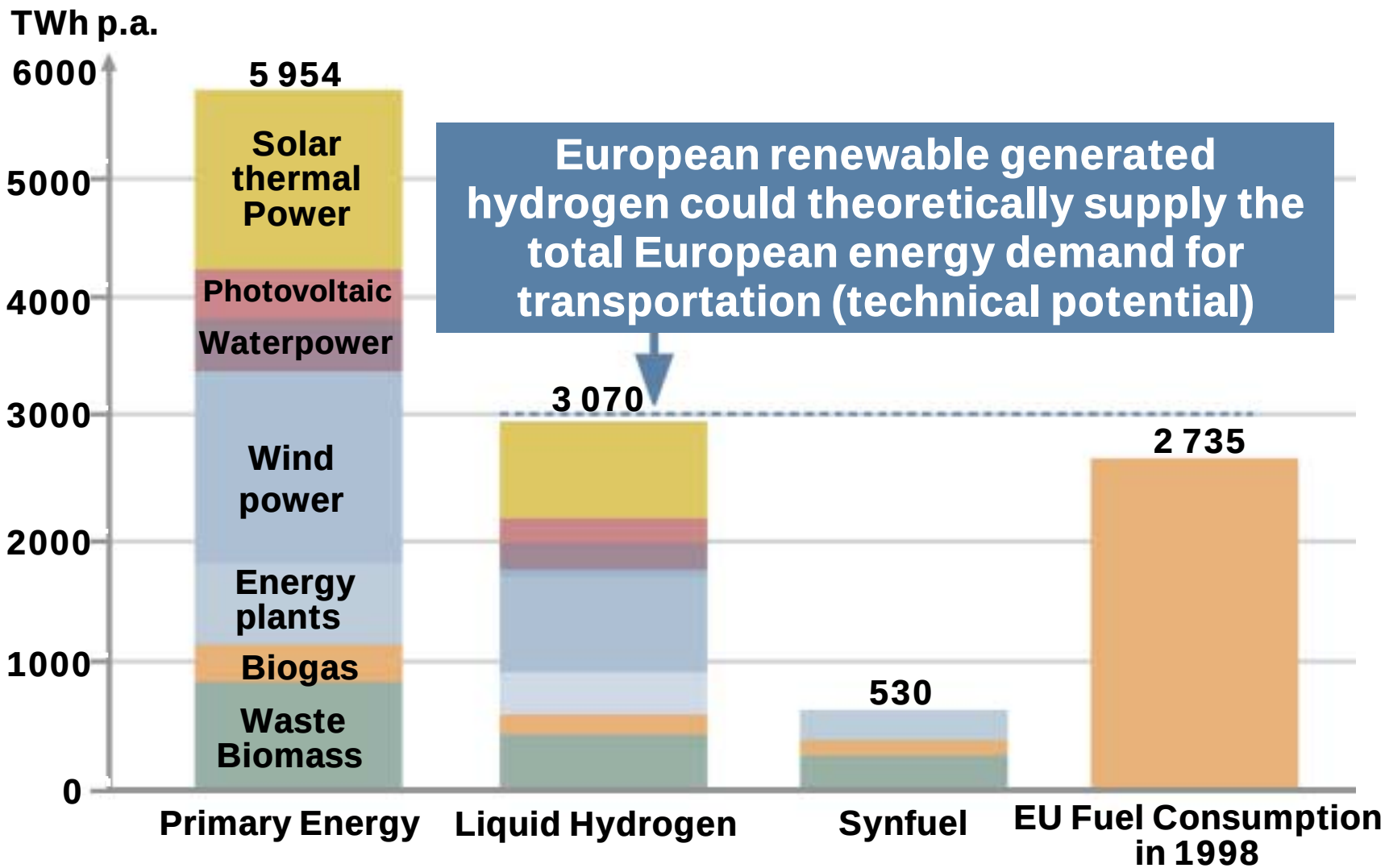
Comparison of Different Fuels



Source: Transport Energy Strategy

Long Term Potential of Hydrogen

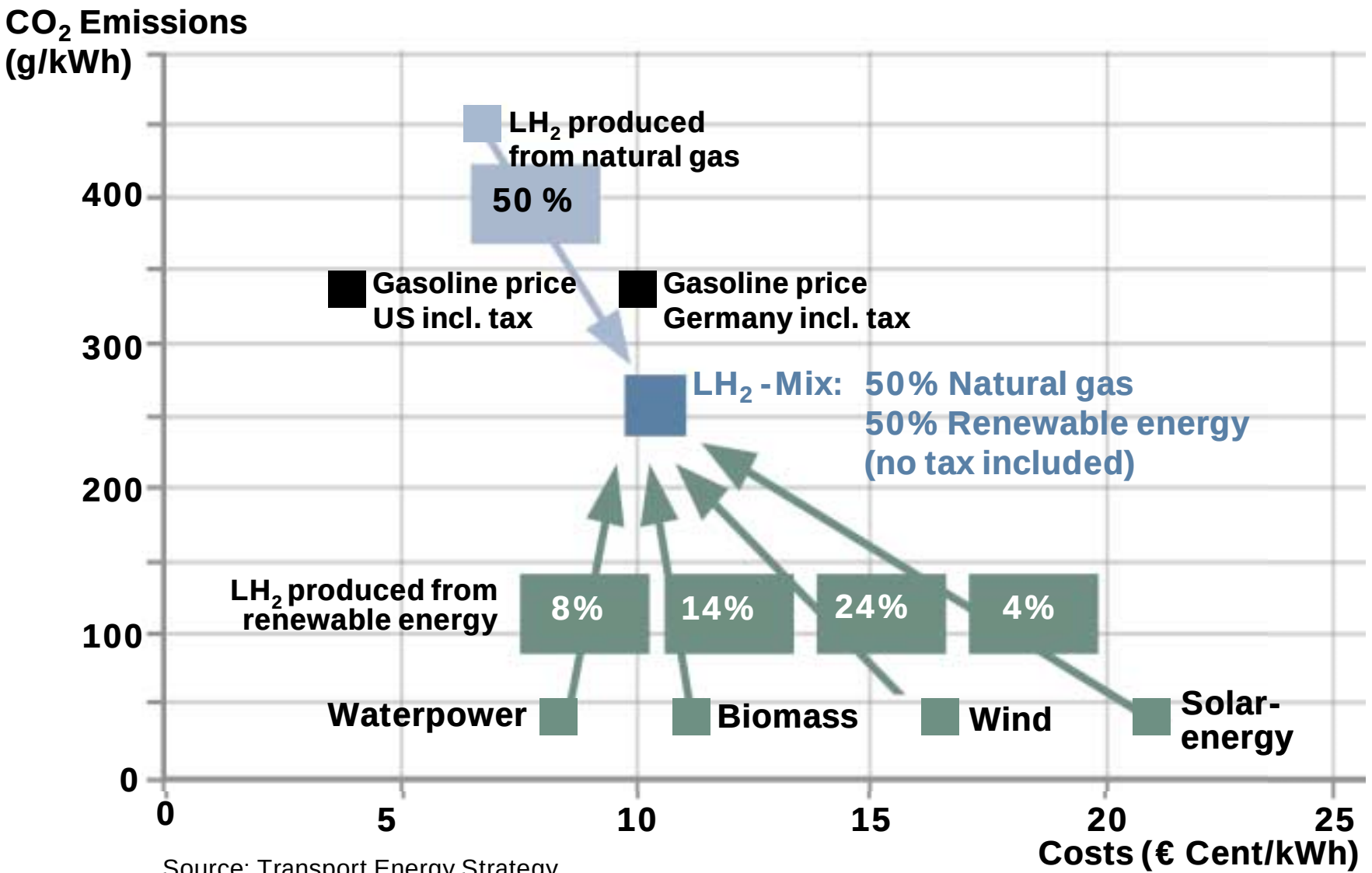
Best of all Alternative Renewable Fuels



Source: Forschungsstelle für Energiewirtschaft, München

Liquid Hydrogen LH_2: Costs and CO_2 Emissions

Comparison of Production Options



Source: Transport Energy Strategy

Different Hydrogen Propulsion Systems
Common Infrastructure Requirements

Internal Combustion Engine ICE:

+ power/weight & power/volume ratio
+ cost-efficient production
+ Proven durability

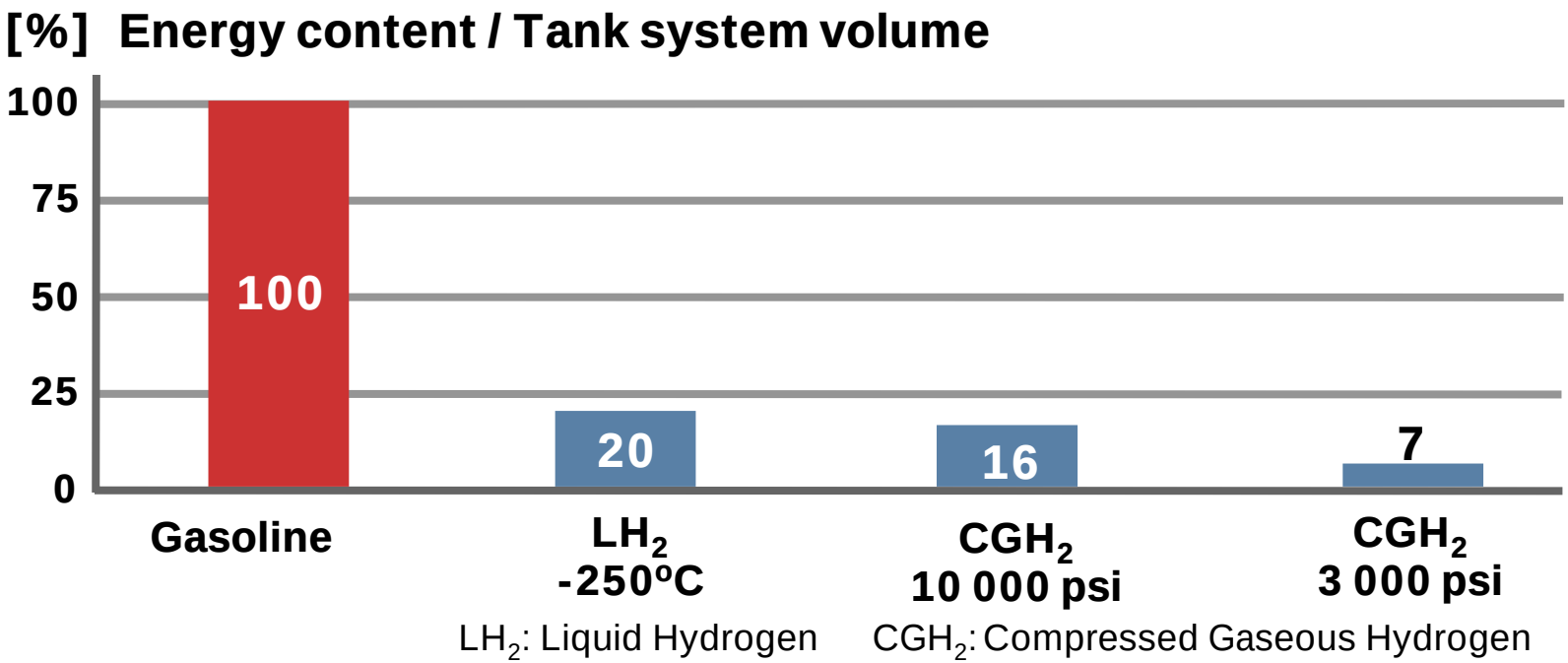
Both drive train concepts include specific advantages and further development potential. The entry into a "hydrogen world" requires both: setting up activities of the petroleum industry and extensive choice of automobiles

Fuel Cell & E-Motor:

+ High starting torque
+ Zero Emission Vehicle
+ Wide-spread public acceptance for urban traffic?

Energy Density of H_2 Compared with Gasoline

Tank System Volume for Passenger Cars



LH_2: Liquid Hydrogen CGH_2: Compressed Gaseous Hydrogen

LH_2 (-250°C) versus CGH_2 (10 000 psi):

+ more cost-effective and approved in practical experience:

LH_2-Transport by truck approx. half as expensive as power supply line

+ less space needed at filling stations:

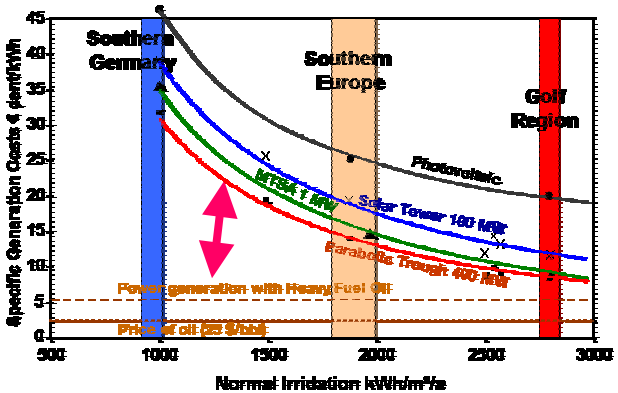
CGH2: Electrolyses on site, 12 000–16 000 psi required at filling station

- less efficient in production:

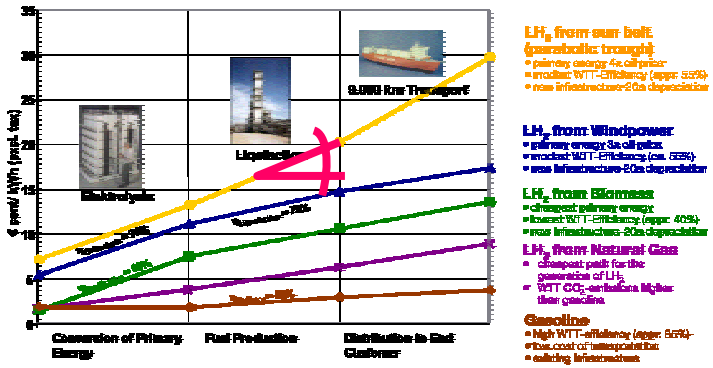
energy losses for liquefaction approx. 2-4 higher than for compression to 10 000 psi

Hydrogen as a Fuel
Challenges and Barriers

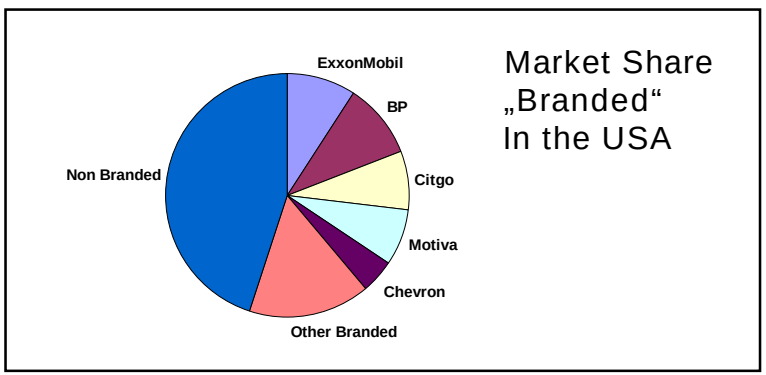
- **Renewable Energies:**
  Close the Gap !
  - ⇨ Mean price of oil over 30 $/bbl
  - ⇨ More research for renewable energies!



- **Costs of hydrogen production**
  Higher η, lower capital expenditures !
  - ⇨ high efficiency keeps cost of operation down (e.g. liquefaction with “green electricity“)



- **Development of H_2-Infrastructure**
  Only together with Oil Industry !
  - ⇨ 175.000 Filling Stations in USA
  - ⇨ Market Share “Branded“ 55%
  - ⇨ “Convenience“



Development of a H_2-Infrastructure
Current Projects at BMW

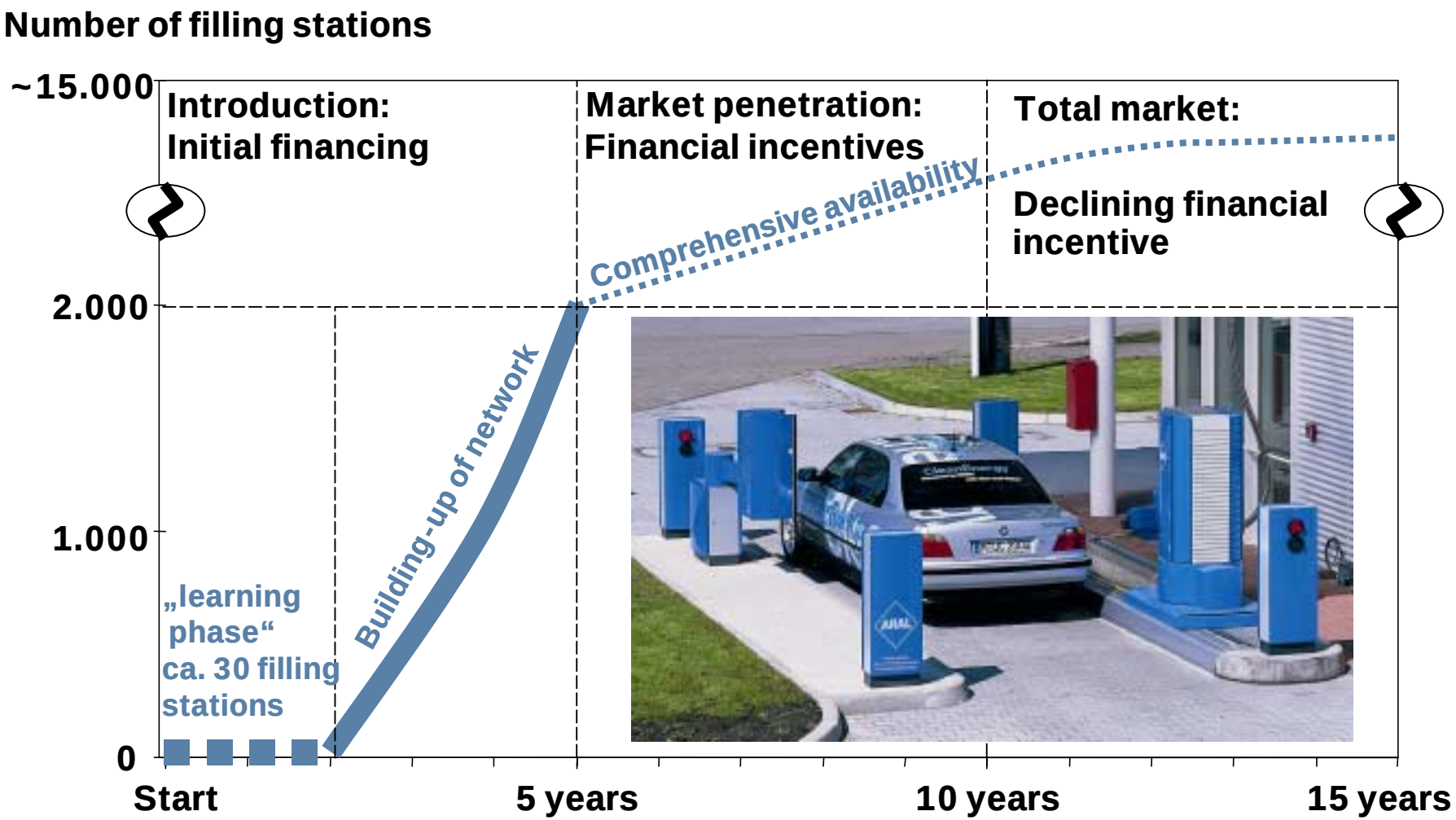
H_2-Production

- ⇨ **Potential of Solar:** “Dubai-Study“ und “World Solar Study“ (FfE)
- ⇨ **Wind-H_2:** “Wind-Study H_2“ (DEWI) Collaboration with Windstream
- ⇨ **Solar-Reforming of Gas:** Collaboration with Solar Systems (in negotiation)

Distribution and H_2 Filling Stations

- ⇨ Transport Energy Strategy to become a European Initiative
- ⇨ Clean Energy Partnership Berlin (CEP Berlin)
- ⇨ TES-EUCAR Initiative for a common European Fuels Roadmap
- ⇨ International Hydrogen Infrastructure Group (IHIG)

Hydrogen Service Station Network
Hypothesis for Setting-up Phase



International Hydrogen Infrastructure Group – First results of "Customer Survey" Study

Customers exspectations to H_2 infrastructure		
	urban areas	**Interurban areas**
known terrain	refueling "unpleasant"	No matter – route planning
unknown terrain	Choice of brand-name stations	"running-out-fear"

Basic infrastructure for H_2: urban > 25% of all filling stations
interurban > 50% of all filling stations

For comparison:
TES-Basic infrastructure assumption: 17% of all filling stations

CleanEnergy
Hydrogen-Cycle

Distribution and Refueling

Usage of hydrogen

Production of hydrogen from unlimited renewable energy resources